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(54) Title of the Invention: LASER HEAT TREATMENT DEVICE

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Specification

1. [Title of the Invention]

LASER HEAT TREATMENT DEVICE

2. [Scope of Claim]

A laser heat treatment device characterized by comprising: a laser oscillator; and a reflecting mirror provided concentrically in a light path of a laser beam emitted from the oscillator, for which a reflecting surface for making a central portion of the laser beam serve as emitted reflective light or dispersed reflective light and a portion other than the central portion of the laser beam serve as parallel reflective light is formed, wherein the reflective surface turns to a direction in which the aforementioned laser beam that has transmitted through an object to be irradiated is reflected to a back side of the aforementioned object to be irradiated.

3. Detailed Description of the Invention

[Industrial Field of the Invention]

The invention relates to a laser heat treatment device with respect to a material such as a semiconductor substrate.

[Technical Background of the Invention and Problem thereof]

Conventionally, a method in which an impurity layer is formed over a semiconductor substrate, ions are implanted in the semiconductor substrate and then a surface thereof is heated with a laser beam to form an impurity diffusing layer over the surface, annealing is performed to recover crystallinity, or the like is used in a manufacturing process of a semiconductor device. However, in the case of using a laser such as a TEA CO_2 laser, which has a large diameter and a narrow pulse width and by which a large output is obtained, a laser output required for heat treatment is obtained even if a relatively wide area is irradiated with a laser beam while the laser beam is not condensed in a fine spot. Therefore, the laser is highly expected as a diffusing heat source for forming a junction of a solar cell or the like. However, since a size of a laser spot is sufficiently large in this case, unevenness of heat treatment is caused over a substrate depending on intensity distribution in a laser beam if irradiation is performed with the laser beam with a large diameter. Accordingly, a pn junction of a solar cell is not formed depending on a place; therefore, photoelectric conversion efficiency is decreased. It is considered that in order to avoid this, the same place is irradiated a plurality of times so as to have a lap, thereby erasing a portion where heat treatment is unfinished. However, the second or later irradiation pulse may destroy a solar cell for which a good pn junction has been formed with the first irradiation pulse, which causes a decrease in performance of the solar cell.

As a conventional method for uniformizing intensity distribution in a cross section of an oscillated beam when laser beam irradiation is performed, small divided mirrors are provided in a laser beam light path, and reflections from these mirrors are overlapped on one surface to uniformize intensity distribution. However, these methods for uniformizing intensity distribution has defects in that a structure of a reflecting mirror is complicated and in that reflection loss of the laser beam occurs and thus the laser oscillated beam cannot be used efficiently.

[Object of the Invention]

A laser heat treatment device capable of evenly raising a temperature of a portion to be irradiated is provided.

[Summary of the Invention]

A structure is that an object to be irradiated which allows transmission of a laser beam is irradiated with a laser beam from one side so that a central portion of the transmitted laser beam having high intensity is made to serve as emitted light or dispersed light to be reflected to a back side of the object to be irradiated.

[Embodiments of the Invention]

FIG. 1 is an embodiment of the invention. (1) is a laser oscillator formed of a solid laser such as a YAG laser, a CO_2 laser; a gas laser such as a TEA laser; or the like. (2) is a condenser provided in the light path of a laser beam (3) outputted from the laser oscillator (1). (4) is a reflecting mirror having a highly reflecting surface (5) provided concentrically with the laser beam (3). An inside of the reflecting mirror (4) is set to be cooled down by cooling water (7) circulating by a water-cooling mechanism (6). The aforementioned highly reflecting surface (5) is formed of a convex spheroidal mirror portion (8) on which a central beam (3a) of the laser beam (3) having high intensity falls and a plain mirror portion (9) on which the laser beam (3) other than the central beam (3a) falls. In addition, (10) is a scanning mechanism which inserts an object to be irradiated of a laser beam transmissive material, for example, a silicon substrate (12) having an impurity dopant layer (11) on a surface thereof between the condenser (2) and the reflecting mirror (4) to shift in XY directions.

In the aforementioned structure, before the laser beam (3) transmits through the silicon substrate (11), a central portion of the impurity dopant layer (11) in a condensing spot is heated

to a relatively high temperature by the central beam (3a), and a portion other than the central portion is heated at a lower temperature than the aforementioned heating temperature by a peripheral beam (3b). Next, the laser light (3) which heats the impurity dopant layer (11) and transmits through the silicon substrate (12) falls on the highly reflecting surface (5). On the highly reflecting surface (5), the peripheral beam (3b) as a parallel beam transmits through the silicon substrate (12) again to reheat a peripheral portion of the impurity dopant layer (11). Further, the central beam (3a) that has fallen on the convex spheroidal mirror (8) is made to serve as emitted light to be reflected, and is emitted to mainly the peripheral portion of the impurity dopant layer (11) while overlapping with the aforementioned peripheral beam (3b) which is made to serve as a parallel reflecting beam, thereby the aforementioned peripheral portion is further heated. That is, at the point of heating the impurity dopant layer (11) with the incident laser beam (3), an area of an irradiation spot is in a unevenly heated state similar to heat distribution of the laser beam (3); however, when an incident beam and reflecting beam are overlapped to be emitted by the reflecting mirror (4) formed of the convex spheroidal mirror portion (8) and the plain mirror portion (9), a peripheral portion excluding a central portion receives larger amount of optical energy of the reflecting beam than the central portion, which leads to a evenly heated state.

FIG. 2 is another embodiment of the invention. It is different from the aforementioned embodiment in that a reflecting mirror (15) formed of a light dispersing surface portion (13) is applied instead of the convex surface mirror portion (8). In this embodiment, the central beam (3a) falling on the light dispersed surface portion (13) is also dispersed and reflected to the peripheral portion of the impurity dopant layer (11) and overlaps the incident beam, thereby a more even reheating effect can be obtained.

In any of the aforementioned embodiments, the impurity dopant layer (11) and a silicon portion of an interface are heated and melted evenly, for example, a pn junction is formed, and a post-process of forming front and back electrodes and a protective film is added to form a solar cell or the like.

[Effect of the Invention]

A laser beam is not emitted to a portion heated to a high temperature to reheat to a high temperature, but emitted while avoiding the portion; therefore, a surface treatment can be

performed by heating and melting evenly without generating heat damage. Accordingly, stability in quality, and yield are significantly improved.

4. [Brief Description of the Drawings]

FIG. 1 is a structure diagram showing an embodiment of the invention, and FIG. 2 is a structure diagram showing another embodiment of the invention.

(1) ··· laser oscillator
(2) ··· laser beam
(3) ··· condenser
(4), (15) ··· reflecting mirrors
(8) ··· convex spheroidal mirror portion
(13) ··· light dispersing surface

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